Beam Optimization

Samuel Rhodes
William and Mary REU
Summer 2013

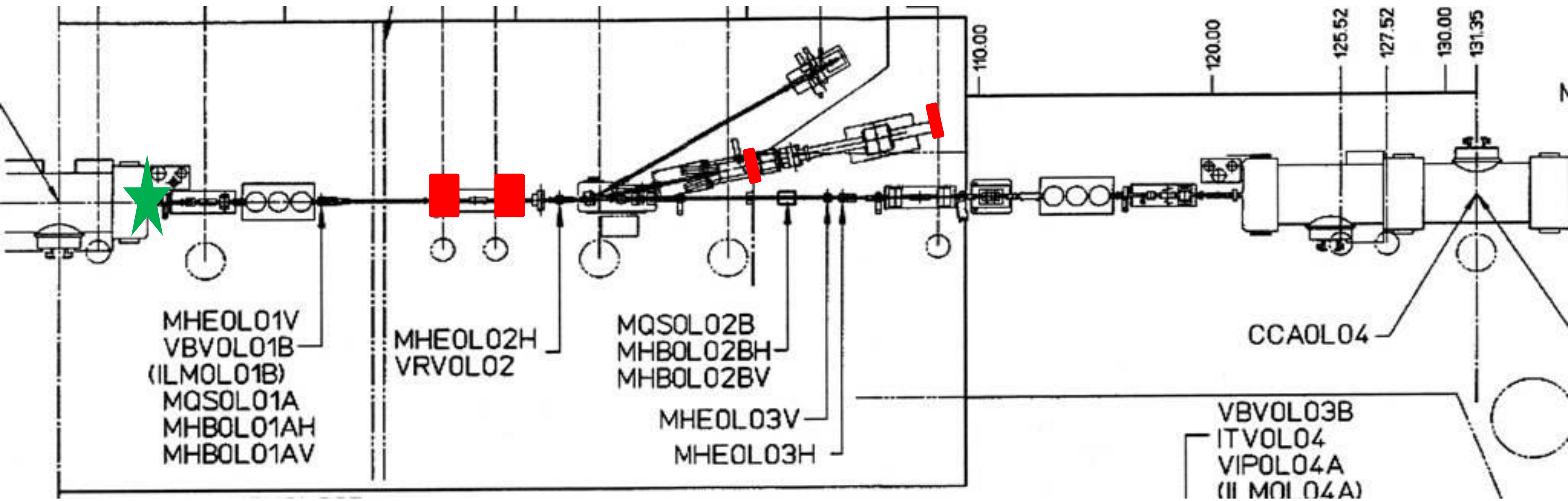
Goals

- Edit PEPPo Elegant file to build Mott beam line

- Define beam line from dipole magnet to the beam dump

- Elegant K value simulation (quad focusing)

- Use *optimize* command to get specific values for σ_x and σ_y at Mott scattering target (beam size)



110.00
120.00
125.52
127.52
130.00
131.35
MHEOL01V
VBVOL01B
(ILMOL01B)
MQSOL01A
MHBOL01AH
MHBOL01AV
MHEOL02H
VRVOL02
MQSOL02B
MHBOL02BH
MHBOL02BV
MHEOL03V
MHEOL03H
CCAOL04
VBVOL03B
ITVOL04
VIPOL04A

Peppo to Mott

- Use Elegant dipole to bend magnet -12.5 degrees instead of the 25 degrees used for PEPPo

```
MBV2D01: CSBEND, L=0.12663237, ANGLE="25  180.0 / -1 acos * ", TILT=0,      &
        E1="00.0 180.0 / -1 acos * ", E2="25 180.0 / -1 acos * ",           &
        EDGE_ORDER=2, HGAP=0.013564, FINT=0.5, NONLINEAR=1, N_KICKS=15, INTEGRATION_ORDER=4

MBV2D01: CSBEND, L=0.12663237, ANGLE="12.5 180.0 / -1 acos * ", TILT=3.14159265359,      &
        E1="00.0 180.0 / -1 acos * ", E2="12.5 180.0 / -1 acos * ",           &
        EDGE_ORDER=2, HGAP=0.013564, FINT=0.5, NONLINEAR=1, N_KICKS=15, INTEGRATION_ORDER=4
```

Beam Line

- Beam line from cryounit to dipole was already there.

- The beam from the dipole to the dump needed to be added.

- Measurements taken directly in tunnel.

Finding arc length of beam in dipole

- Worked backwards from PEPPo file. α=bend angle, ρ=bend radius. Length units=meters

$$L_{arc} = .12970672 = \rho\alpha = \frac{5\pi}{36}\rho$$

$$\rho = .29726591$$

$$l_{eff} = \rho\sin(\alpha) = .12563000$$

$$\rho = \frac{\sin(12.5)}{.12563000} = \frac{\sin(.2182)}{.12563000} = .580350$$

$$L_{arc} = \rho\alpha = .580350(.2182) = .12663237$$

K1 – Quad Modeling in Elegant

- K values are scaled by the strength of the magnetic field. You can find the maximum K value by looking at the strongest possible field the magnet can produce. For "QJ" quadrupole magnets that value is found in the second equation line below.

$$K = .2998\frac{GeV}{T*m}*\frac{B_o}{a}\frac{T}{m}*\frac{1}{\beta E} = .2998\frac{GeV}{T*m}*\frac{B_o}{a}\frac{T}{m}*\frac{1}{pc}$$

$$\frac{B_o}{a}L = .6\frac{kG}{cm}cm$$

$$\frac{B_o}{a} = .04\frac{kG}{cm} = 4000\frac{G}{m}$$

$$K = .02998\frac{MeV}{G*m}*4000\frac{G}{m}*\frac{1}{p}\frac{1}{MeV} = \frac{119.92}{p}\frac{1}{m^2}$$

“K1” Simulation Results

- Goal was to get a beam of approximately 1 mm in both the x and y. Just experimenting with different K1 values, I was able to get pretty close. However, these are the sigma values at the dump and not the target.

MQJ0L02 K1	MQJ0L02A K1	Sigma_x (m)	Sigma_y (m)
2.907078	1.812964	1.035043e-3	1.111371e-3
2.921342	1.916924	1.046936e-3	1.138642e-3
2.657921	1.996578	1.025268e-3	1.104405e-3
1.997078	1.996578	9.614413e-4	9.703368e-4
1.197078	1.196578	8.956815e-4	6.378307e-4

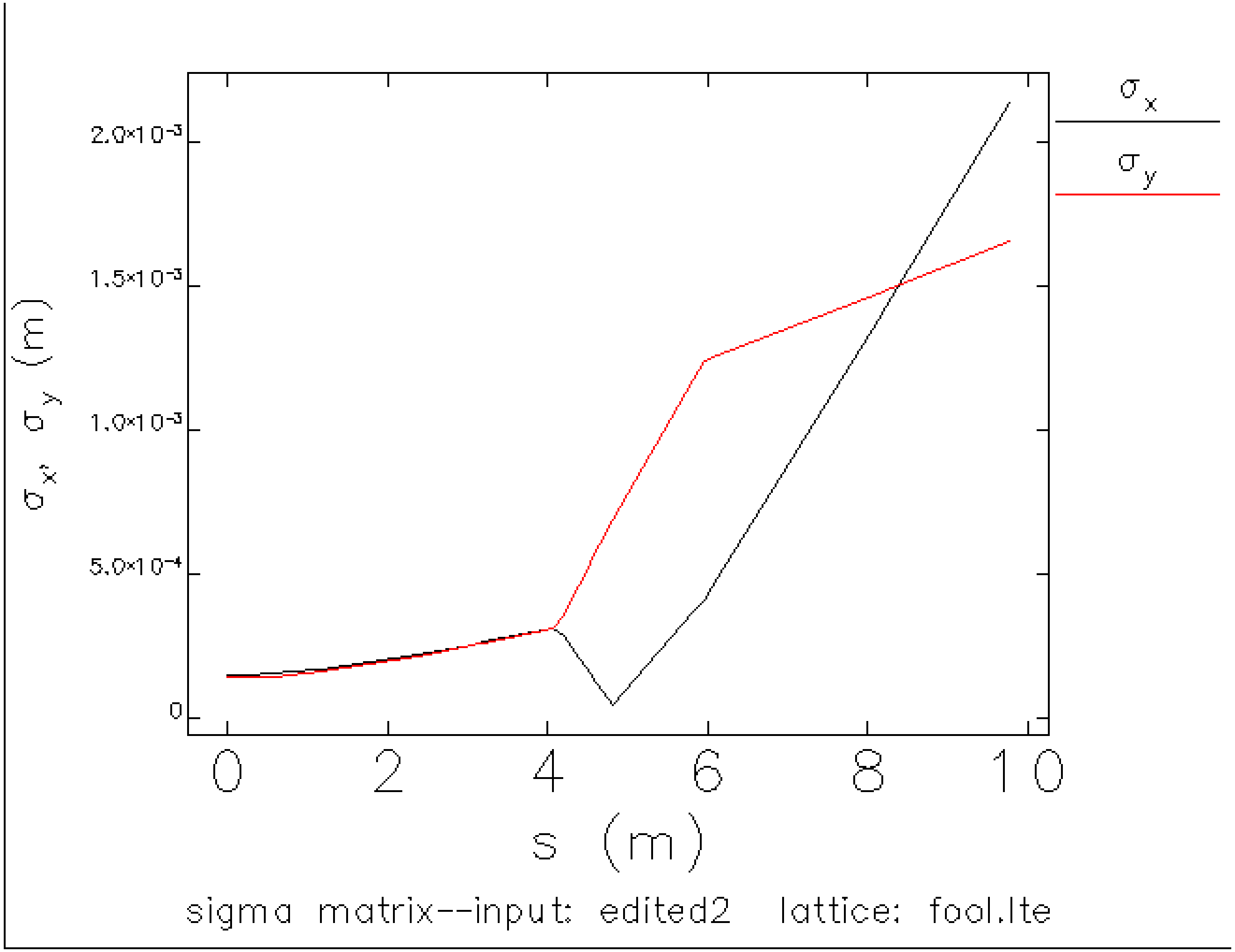
Elegant Optimization

```
&optimization_variable
name= MQJ0L02, item= K1, lower_limit=-100, upper_limit=100, step_size=1
&end

&optimization_variable
name= MQJ0L02A, item= K1, lower_limit=-100, upper_limit=100, step_size=1
&end

&optimization_term
weight=1,
term="ITG2D00#1.Sx .001 - sqr",
&end

&optimization_term
weight=1,
term="ITG2D00#1.Sy .001 - sqr",
&end
```

Optimized Sigma Values

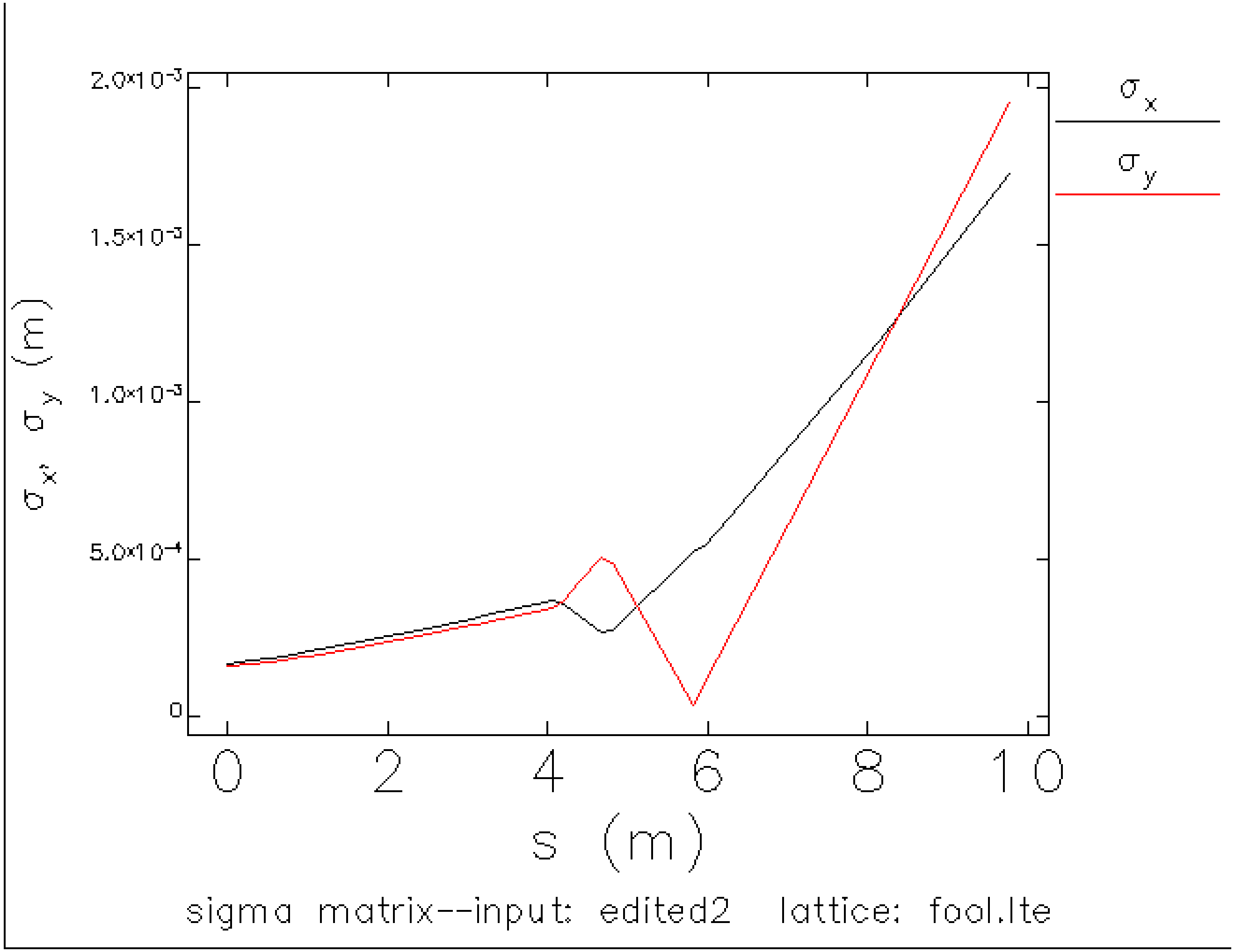
P (MeV/c)	Max K1	MQJ0L02 K1	MQJ0L02A K1	Sigma_x	Sigma_y
8.3	14.448	-13.44256…	4.820806…	1.5 mm	1.5 mm
6.3	19.0349	4.5010734…	-10.72985…	1.25 mm	1.25 mm
5.5	21.8036	-10.69554…	4.996516….	1.5 mm	1.5 mm
4.2	28.552	-9.999483…	4.863679…	2 mm	2 mm
3.2	37.475	-9.890956…	4.963274…	2 mm	2 mm

8.3 MeV Graph



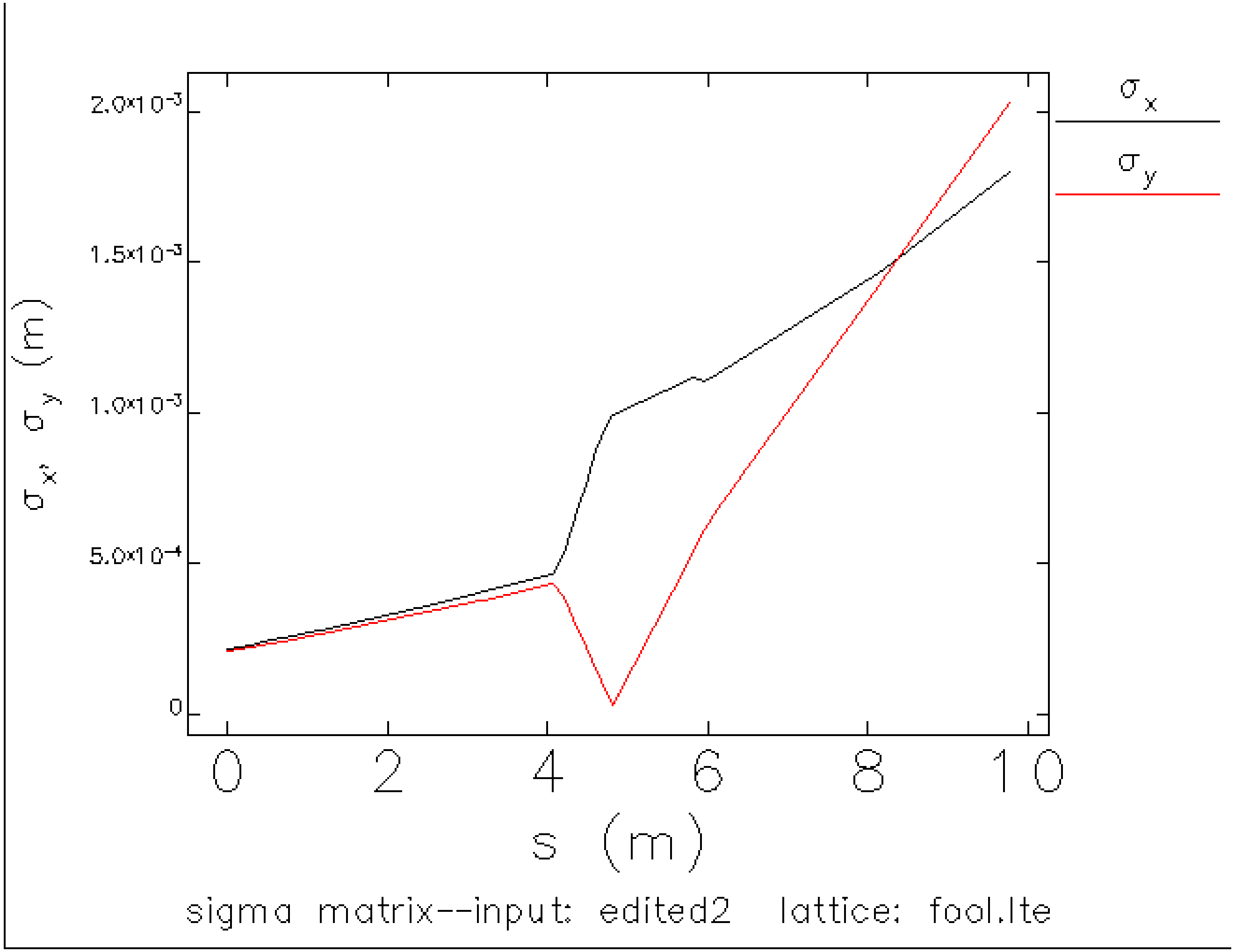
σx
σy
2.0×10⁻³
1.5×10⁻³
1.0×10⁻³
5.0×10⁻⁴
0
σx, σy (m)
0
2
4
6
8
10
s (m)
sigma matrix--input: edited2 lattice: fool.lte

6.3 MeV Graph



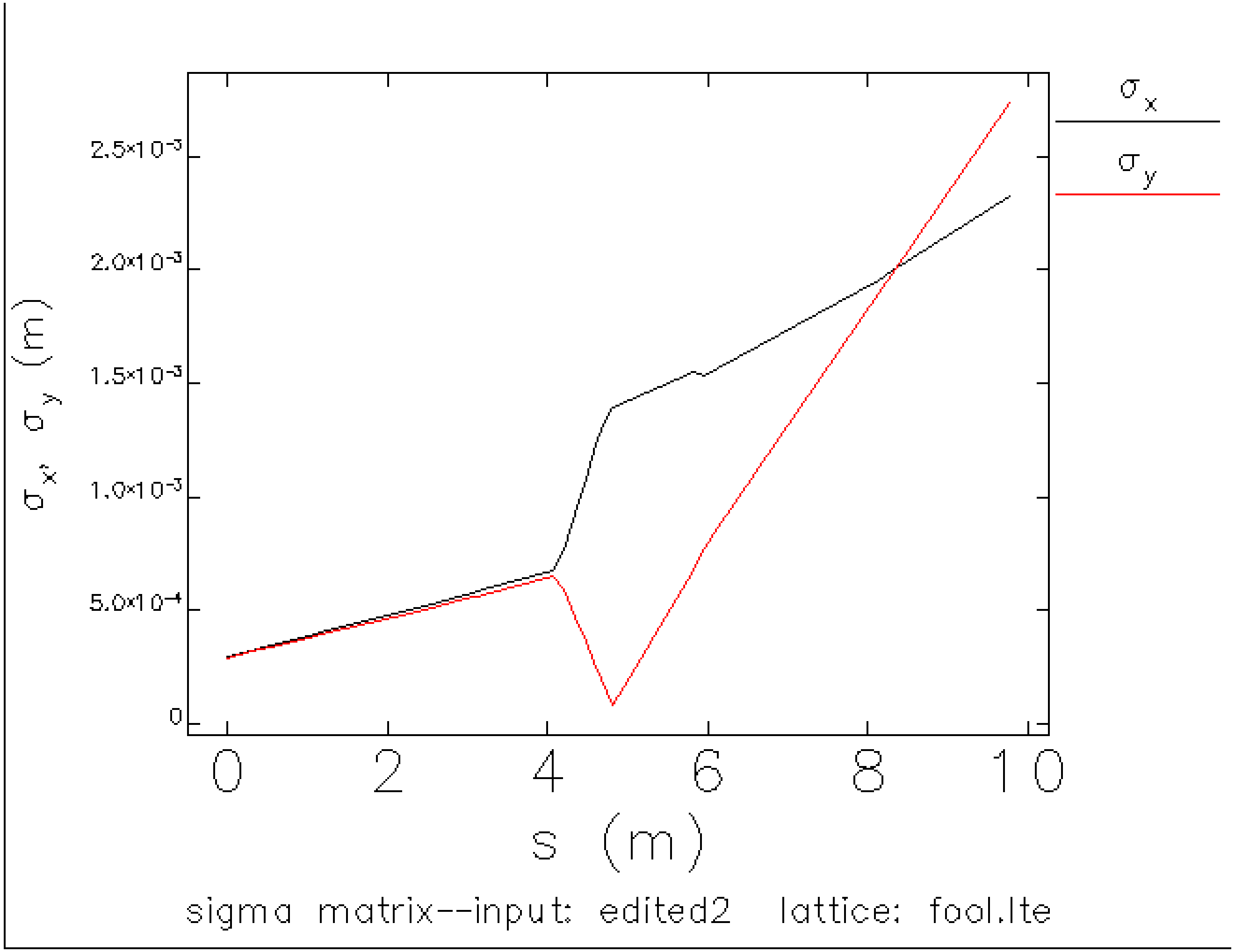
2.0×10⁻³
1.5×10⁻³
1.0×10⁻³
5.0×10⁻⁴
0
σx, σy (m)
0
2
4
6
8
10
s (m)
σx
σy
sigma matrix--input: edited2 lattice: fool.lte

5.5 MeV Graph



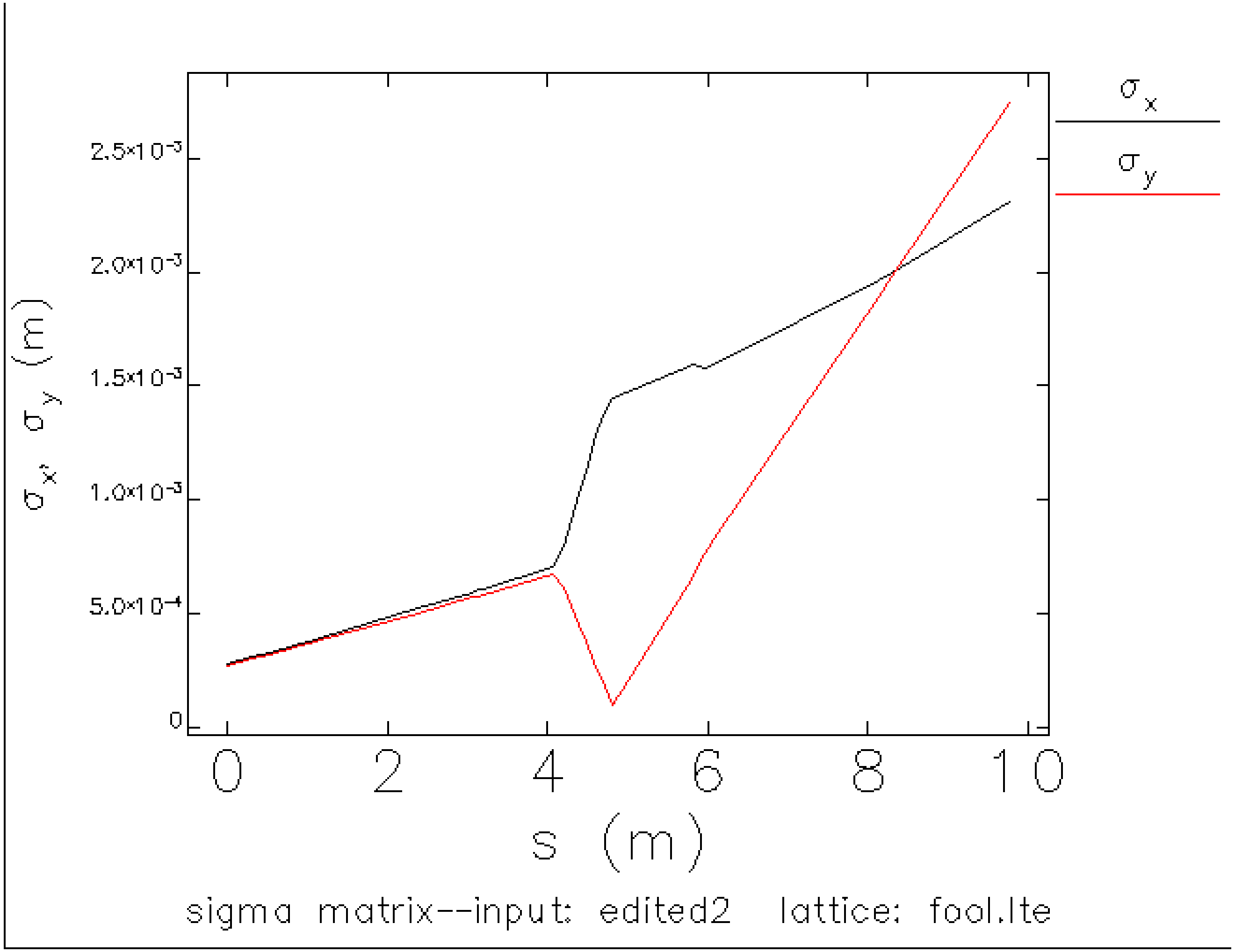
2.0×10⁻³
1.5×10⁻³
1.0×10⁻³
5.0×10⁻⁴
0
σx, σy (m)
0
2
4
6
8
10
s (m)
σx
σy
sigma matrix--input: edited2 lattice: fool.lte

4.2 MeV Graph



σx, σy (m)
2.5×10⁻³
2.0×10⁻³
1.5×10⁻³
1.0×10⁻³
5.0×10⁻⁴
0
0
2
4
6
8
10
s (m)
σx
σy
sigma matrix--input: edited2 lattice: fool.lte

3.2 MeV Graph



σx
σy
2.5×10⁻³
2.0×10⁻³
1.5×10⁻³
1.0×10⁻³
5.0×10⁻⁴
0
σx, σy (m)
0
2
4
6
8
10
s (m)
sigma matrix--input: edited2 lattice: fool.lte